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SMUT-FUNGI.

RECENT DISCOVERIES AS TO THE NATURE AND ACTION OF USTILAGINEÆ.*

It is hardly too much to say that the man who clears up the life history of smut-fungi and gives to the world an intelligible account on which a successful treatment can be based, realizes the proud achievement of making two blades of grass grow where only one grew before—a feat worthy of the most devoted consideration of citizens and statesmen, as we have been told on high authority. Perhaps the honor is already due to those botanists—Kühn, R. Wolff, De Bary, and Brefeld—who, following on the earlier and chiefly anatomical investigations of Fries, Persoon, Corda, Meyen, Léveillé, Bonorden, and especially the Tulasnes, gradually demonstrated the biological nature of the *Ustilagineæ*, those subtle fungi which cause the smuts of cereals and onions, etc., the bunt of wheat, and a large number of similar diseases on all kinds of valuable plants.

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For many years previous to about 1840 little was known of these fungi beyond the fact that the bunted or smutted grains of corn were transformed into a dark, powdery mass of minute spores. Somewhat later (I believe first by Bonorden, in 1851) it was found that although, when ripe, there is nothing but spores in the blackened grain of corn, etc., in a somewhat younger condition these spores can be shown to arise from delicate fungous filaments, just as in the case of other fungi. At any rate, this was known to De Bary in 1853, from his own researches on the smuts of maize and other plants, and is now thoroughly established. But although it is now very easy to show the fungous filaments, or mycelium, in the case of some *Ustilagineæ*, they are in others so delicate and so transparent that the most refined methods and practice are necessary to demonstrate their presence. Nevertheless, the dark spores in all cases arise in tufts from the ends of more or less fine filaments. In some cases these filaments have distinct walls and septa, and send suckers (haustoria) into the cells of the tissues; in others they are so minute that it is extremely difficult to say whether they consist of anything more than strands of protoplasm. In some species they are abundant, in others sparse. In many species these fungous filaments can be traced for considerable distances from the diseased spots; in others they are confined to local centers. These characters, as well as other peculiarities respecting the branching, mode of spore formation, gelatinization of the walls, etc., need not occupy us here however, though they are of importance to the mycologist.

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* H. Marshal Ward in Gardener's Chronicle, Vol. V, p. 233.

GROWTH OF THE FUNGUS.

The outcome of all this may be summed up as follows: When the spore is allowed to germinate in water the tough outer skin bursts, and a thin hyaline cellulose membrane inclosing the swelling protoplasmic contents emerges as a delicate tube. In some cases this tube protrudes through a definite thin spot; in others no germination could be induced in water, even though plenty of air was present and the temperature normal. The older the spore the longer the time required before germination.

When the above germinal tube has attained a length of, say five or six times the diameter of the spore, it breaks up into segments, and begins to put out numerous bud-like branches, which soon separate as single cells, looking very like cells of the yeast plant. These yeast-like cells have usually been called sporidia. In some species the sporidia are long and thread-like, and are produced in a sort of coronet. Other varieties in detail occur, but our purpose is served if the reader apprehends that the usual mode of germination in water is for the spore to put forth a short tube (the so-called pro-mycelium), from which several sporidia are then budded off.

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HOW AND WHERE THE FUNGUS ENTERS THE PLANT.

The first steps in the elucidation of the extremely difficult problems here involved were taken by Hoffman, Kühn, and Wolff during the period between 1866 and 1880. Kühn was the first, I believe, to actually perceive the penetration of the fungus into the plant. He showed that if the spores of the bunt fungus (*Tilletia*) are sown with the wheat grains they germinate and produce their promycelia *pari passu* with the emergence of the radicle of the young wheat seedling; from the promycelia are developed the now well known sporidia, and these sporidia then put forth extremely fine fungous filaments, which penetrate the young and delicate tissues of the embryo wheat plant, somewhere in the part (collar) common to root and shoot. Kühn repeated his experiments successfully with the smut of corn, and with several other species, always finding the incipient mycelium of the fungus in the delicate collar. After some years of research Kühn concluded that the normal mode of infection common to the majority of these fungi is the following: The spores ripen in the smutted and bunted cereals with the grain, and are garnered with the latter; they become scattered on the healthy grains, and may be sown in the following spring with these. As the young cereal germinates, the attached spores produce their promycelia and sporidia, and the germ-tubes from the latter penetrate the embryo corn plant. But now came the *crux*. If the fungus is such a virulent parasite as it was made out to be, how is it that we see little or no more of its effects until the late summer and autumn, when the grain begins to ripen? It is true, refined investigations proved that the mycelium could be discovered in small quantities in the corn plants as they grew larger and older, but it seemed to do no harm; but are we to believe that this mycelium can go on growing in and with the tissues of the corn plant, only to exert their destructive effect months afterwards as the grain begins to ripen?

Astonishing as this may seem it turned out to be the case. R. Wolff in 1873 repeated Kühn's experiments with smuts, etc., and practically confirmed them in every particular; it is true he went a little too far in concluding that only a certain organ (the first leaf sheath) is susceptible to the infection, and Kühn's results were shown to be more accurate in this respect, but the primary fact remains that the sporidia are able to effect an entry into the host-plant by means of their germinal tubes only, provided they attack the embryonic tissues, and especially the cells of these delicate young embryos; once inside, the delicate fungous filaments grow on with the tissues, gradually permeating every part of the plant until, with the development of the young fruit, they meet with the conditions for the fulfillment of their own last purpose—the production of spores. Further investigations only succeeded in demonstrating the correctness, in all essential particulars, of these views.

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DRESSING.

As early as 1781, and even earlier, several observers had satisfied themselves of the infectious character of these diseases, and even in 1820 it had been shown that washing the seed corn with copper-sulphate before it was sown resulted in a diminution of the number of diseased ears; and many interesting experiments were made from time to time tending to prove that (1) if smutted grains are mingled with clean ones, the sowings give an enormously higher percentage of diseased ears; (2) the more the seed-grain is cleaned from adherent spores, the less the percentage of diseased ears; (3) it is only in the early stages of the germination of the grain that the danger of the infection is great.

It was from this foundation that the now well-known process of "dressing" wheat took its origin, and to this may be added some "practical" measures introduced as the outcome of experience, and taught empirically. Let us glance at the results in the light of what is already known. One of the commonest and best-known methods of "dressing" is to steep the grain for some hours in a dilute solution of copper-sulphate in water. The object is to cause so much of the poisonous salt to stick to the coats of the "seed-grain" as will kill the delicate promycelia and sporidia before the latter can penetrate the young corn plant. The chief danger is lest the young seedling should have its delicate tissues injured. Other dressings are used in addition to the above; salts of lime, soda, etc., arsenic, permanganate of potassium, carbolic acid, and many other substances have been tried and advocated, and various processes for steeping or washing the grain, or for blowing off spores with powerful draught of air, have found more or less favor. In all these cases the result aimed at is to keep the germinating wheat, etc., from contact with the spores, and no one is likely to call in question the wisdom of the intention.

But another question obtrudes itself here, and that is: If the sporidia can really infect the young wheat seedling, etc., only in the stage and at the place described, then should it not be possible to attack the question of protection from another stand-point? In other words, if the fungus can only enter the tender tissues at the collar of the young seedling, then a few hours more or less in the time occupied in the process of germination may make all the difference to the seedling. All these conditions or adaptations which hurry or facilitate the vigorous germination of the seed must lessen the danger of infection, and if it can be shown conclusively that this is the case, an important service to the community has once more been rendered by the biologists. The ground is a little difficult, however, because, unless we are quite sure of our steps, it is somewhat easy to go astray from facts to hypotheses.

MUCRONOPORUS, E. & E.

By J. B. Ellis and Benj. M. Everhart.

The following additional species of *Polyporeæ* have the hymenium spiny:

Mucronoporus *ferruginosus* (Schrad.) issued in N. A. F., 111, as *Polyporus contiguus*, Pers. The N. A. F. specimens were determined by Berkeley some twenty years ago from specimens sent him from Newfield, N. J. Spines abundant, well developed, 30–40 by 5–6μ. Specimens on osage-orange from Missouri (Demetrio, No. 138), and on *Vitis* from Ohio (Morgan, 577), agree in all respects with the Newfield specimens. In Fr. Epicrisis the pores are said to be equal ("æqualibus"). In N. A. F., 111, they vary from round to flattened and subsinuous, and agree in all respects with three specimens of *Poria ferruginosa* (Schrad) from Herb. Berkeley (kindly sent with many other things by Dr. M. C. Cooke). The N. A. F. specimens also agree much better with the description of *P. ferruginosa* than with that of *P. contigua*, and we have very little doubt in referring them to that species.

The specimen of *P. contiguus* in Rav. Fungi Car. I, 16, has the pores equal and round, or nearly so, and judging from specimens in our Herb. from Morgan (74 and 324) are the same as the "*P. unitus*, Pers." in "The Flora of the Miami Valley." The Ohio specimens are on wood of deciduous trees, and the same thing is not uncommon around Newfield on dry dead limbs of oak. Colonel Calkins also sends it from Florida (Nos. 65, 114, 126, 131) on dead limbs of various deciduous trees.